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Decision aids, even well designed ones, have demonstrated a wide range of utility and effectiveness when employed in the operational environment. The development and employment of the PROPHET HF (1-50 MHz.) propagation assessment system has been observed for over a decade. Recent studies indicate that some of the early assumptions on how the module was to be employed were invalid. Although it uniquely fills a real need and its models and products have been extensively tested in operational environments by its users, which include most military and civilian branches of the U.S. Department of Defense, PROPHET faces an uncertain future as a stand-alone system. Its main strength is to provide mission oriented and scenario specific products to perform HF signal coverage, signal vulnerability and radio circuit connectivity in near real time. While technically sound in meeting these objectives, PROPHET'S effectiveness is limited by variations in user training, experience, motivation and the lack of operationally convenient access. These problems appear to apply in some degree to the employment of most decision aids. Based on the PROPHET experience, this paper will describe the fallacies that are common in decision aid development and employment, how they affect the DA effectiveness, a recommendation for the next generation propagation assessment decision aid and results from an initial demonstration prototyping effort to check out some of the new concepts.

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PROPHET AND FUTURE SIGNAL WARFARE DECISION AIDS

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ABSTRACT

Decision aids, even well designed ones, have demonstrated a wide range of utility and effectiveness when employed in the operational environment. The development and employment of the PROPHET HF (1 - 50 MHz.) propagation assessment system has been observed for over a decade. Recent studies indicate that some of the early assumptions on how the module was to be employed were invalid. Although it uniquely fills a real need and its models and products have been extensively tested in operational environments by its users, which include most military and civilian branches of the US Department of Defense, PROPHET faces an uncertain future as a stand-alone system. Its main strength is to provide mission oriented and scenario specific products to perform HF signal coverage, signal vulnerability and radio circuit connectivity in near real time. While technically sound in meeting these objectives, PROPHET's effectiveness is limited by variations in user training, experience, motivation and the lack of operationally convenient access. These problems appear to apply in some degree to the employment of most decision aids. Based on the PROPHET experience, this paper will describe the fallacies that are common in decision aid development and employment, how they affect the DA effectiveness, a recommendation for the next generation propagation assessment decision aid and results from an initial demonstration prototyping effort to check out some of the new concepts.

PROPHET: PAST, PRESENT AND FUTURE

PROPHET is the Navy's standard tactical HF prediction decision aid. It is designed to provide real-time information about HF signals warfare and the connectivity of radio communication circuits. Since its inception, PROPHET's development has emphasized operational deployment. Its output products have been designed, to a large extent, at the direct request of its operational users.

PROPHET is a self-contained, software system which was conceived in 1974 and first deployed in 1976. It has grown from an initial 5 output products to its present 25 product capabilities, each of which has several sub-options. The most recent release, Version 3.2, has been provided to several hundred users. It uses simple emulations of complex propagation phenomenon to achieve the portability and speed of personal computers. PROPHET contains large amounts of empirical and intuitive knowledge and user experience, lending it the attributes of an expert system. Throughout its development and employment, the models in PROPHET have undergone extensive verification against "ground truth"

oblique-sounder data. Its developers have maintained a continuous dialogue with the user community to ensure continuing operational credibility. This has resulted in a broad spectrum of applications and users.

Today PROPHET's future as a stand-alone capability is in doubt. In spite of it's widespread use and usefulness, PROPHET has not been institutionalized or achieved the programmatic acceptance required to sustain, enhance, and promulgate it. Further development and promulgation remain an Ad Hoc process. This situation prompted PROPHET's developers at NOSC to review the fundamental philosophy of developing and implementing decision aids for the military community. This in-house review indicated errors were made in the assumptions on how the decision aid would be normally employed and identified ways to correct the problems. The remainder of this paper summarizes these findings, proposes recommendations for the next DA's, and describes the results from an initial prototyping effort to check out some of the new concepts.

MAJOR FALLACIES IN DEVELOPING TACTICAL DECISION AIDS

Decision aids (DA), as a generic set of software, typically suffer from at least two fallacies in their concept and development. The first fallacy is that when the user interface is designed, the developer assumes the end user will have the background to ask the right questions in the right order. For example, when each PROPHET module was conceived, it was assumed the user would have the training or experience in HF signals warfare or frequency planning to know the logical inquiry sequence to successfully solve the problem. Review of PROPHET users and the platforms where it has been used indicates that was not a valid assumption. In fact, with respect to HF operations in general, it is more valid to assume the contrary. In numerous operational tests, it has been observed that PROPHET users span a broad spectrum in motivation and HF experience. The higher the motivation, the more the DA was employed and the more of its capabilities were exploited. In general this motivation was derived from desire to do the best job possible and from success in using HF. A highly motivated user wanted to exploit PROPHET to its fullest. He knew the propagation medium, the equipment he was using and how to use PROPHET. The HF signals problems were viewed as a challenge to be overcome. Consequently this persons efforts to use PROPHET were successful. This individual soon acquired considerable expertise in using PROPHET and soon became a "key" person in this aspect of normal operations. But eventually this "key" individual would transfer and, often, was replaced by person who could be considered an "antithesis" to the "key" person - a person with little motivation and little or no experience in using the HF medium. If this user, who would rather guess than do any real problem solving, attempted to use PROPHET for frequency planning at all, the attempt was half-hearted with a low probability of success. This self-inflicted bad experience then snowballed, and served as an excuse to not use PROPHET, or any decision aid, again. This, in turn, caused a reduced reliance on

mission and the DA system's recommendations as to sensor employment. However the final result did reflect consideration of such complex factors as propagation, solar activity, network geometry, and historical sensor performance. The knowledge-based architecture allowed the system to routinely access and peruse large databases for each event. Additional features were included to allow the user to intervene at any level, depending on motivation and experience.

CONCLUSIONS

The survey of PROPHET users indicated that the successful deployment of stand-alone a decision aids is vulnerable to the motivation and experience of the user. In addition its employment is heavily influenced by how readily accessible it is to the intended user in his operational environment.

The next generation decision aid will be a hybrid system which will combine knowledge-based expert systems with traditional algorithmic functions such as those in PROPHET. The expert systems will specify, setup, and control complex HF connectivity and signal assessment calculations from PROPHET-like models which and carry on the query-response dialogue with the user. To ensure that it is readily accessible operationally, critical issues in the DA's early design are (1) what mission it supports; (2) specifically who the users are and how much time they can devote to the DA operations; and (3) where the DA will be physically located.

The development of the NOSC Advanced HFRLS demonstration terminal provided lessons that are critical in achieving and fully exploiting the next generation decision aid. It was shown that:

(1) Algorithmic signal-assessment systems, such as PROPHET, can be subordinated and tasked by a knowledge based system. This makes the employment of high-level propagation and signal-warfare models transparent to the user.

(2) Subjective information, such as sensor operator experience, sensor performance, and historical trends and characteristics can be employed in the decision process or in the information displayed.

(3) Rule-based expert-system technology allows rapid, intelligent perusal of immense amounts of data which is critical in the control and employment of a large communications or surveillance network. It further provides the basis for "knowledge cloning" which is critical in preserving HF technology.

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Decision aids, such as PROPHET, are based upon deterministic calculations. The problems amenable to PROPHET for analysis are those for which technical methods provide explicit solutions. However, many other HF/VHF radio operations problems are not amenable to such explicit analysis. An example of this latter situation is the prediction of when and where sporadic-E will occur. Sporadic-E has a profound effect on both HF and VHF systems but can only be described in qualitative terms (e.g.it occurs in May and June at local Sunset and drifts from the southeast to northwest). One of the most promising methods of being able to deal with problems that don't lend themselves to deterministic solution is the Expert System. An Expert System is a computerized implementation of the analytical processes that a human expert employs in his profession. The major elements of an Expert System include the "knowledge base" and the "inference engine". The "knowledge base represents the body of information relevant to the problem under scrutiny and may contain "subjective" rules of the sort used by human experts based on experience; from these rules, the system can construct heuristic solutions. The "inference engine" contains the inference and control strategies that are used to evaluate the knowledge base and synthesize solutions. Expert systems also have the feature of being "knowledge clones" which serves to preserve expertise in various technologies. This is particularly needed in the preservation of HF technology, which has significantly eroded since the middle 1960's.

In 1987/88, developmental work was conducted at the Naval Ocean Systems Center to combine the capabilities of presently-available knowledge-based expert system technology and algorithmic HF propagation-assessment systems such as PROPHET. A module, called the HF Radiolocation System (HFRLS), was developed to test and demonstrate this hybrid concept. The initial software test vehicle was to perform resource management on a hypothetical network of dissimilar HF radiolocation sensors. These included shore-based wide-aperture HFDF systems, shipboard HFDF systems, single site locator systems and receive-only HF acquisition systems. The purpose of this system was to perform (1) scenario assessment, (2) resource availability and capability assessment, (3) tasking to sensor subnets, and (4) assessment of the decision on whether or not to select a particular sensor. The system was structured so that the operator would start to converse with the system at the start of an event and would monitor progress up through the final solution and output product.

In-house testing of HFRLS indicated that using an "intelligent" man-machine interface greatly enhances the employment of the basic decision aid. The major propagation models in PROPHET were subordinated to the HFRLS system. The knowledge based system "knew" when propagation data was necessary, the right questions to ask PROPHET, and how to format them correctly. This was an internal dialogue that required no user intervention, so the propagation models were completely transparent to the user. The user saw only information needed to perform a radiolocation

the decision aid, further eroding the motivation. When allowed to continue, this degenerative cycle eventually eroded all the progress gained and ultimately the DA was discarded altogether.

The key feature in defeating this negative cycle is to design a user interface that will assure the new decision aid user with the same high level of success, irrespective of motivational level or experience.

The second major fallacy in designing and employing signal assessment decision aids is to assume there will be sufficient time and manpower in the operational environment for them to be used. Generally this is not the case, especially on afloat or airborne platforms. As an example, consider the initial deployment of Classic PROPHET II which was designed to support OUTBOARD HFDF operations. The module was designed specifically to meet the needs of OUTBOARD operators in predicting periods when signals of interest could be expected to be heard. Ships personnel were thoroughly trained in using it on a stand-alone personal computer. However, when the ship got underway, the intended user's time was fully consumed manning their primary positions. There was no extra time to perform the necessary supporting calculations off line, even though the dedicated computer was physically only few feet away. Although the capability was fully functional, its stand-alone location made it impractical for the user to access it.

This experience indicated that a signal assessment decision aid must be embedded into the system it is supporting.

THE NEXT GENERATION DECISION AID

New requirements have been proposed for the next generation of signal assessment decision aid. The proposed design was influenced by the experiences that were just discussed. It must be able to achieve the same high level of performance or productivity regardless of the experience and /or motivation of the user, and must be embedded into the system it is supporting.

The interface of the next generation DA must allow the user to converse with the system in plain language or in the jargon of the specific mission. Expanding telecommunications will make larger amounts of information available to problem solving and the DA must have the ability to peruse these data. Complex scientific calculations, such as those used for propagation and solar-terrestrial relationships will be performed in the computer background, outside the user purview. In many cases, very complicated models, such as those used in PROPHET, will be totally transparent to the user....they will be applied to a users problem in a normal manner, and the result will reflect their use, but their actual operation will not appear in the user system dialogue.